STANDARD REFERENCE MATERIALS FOR RADIOACTIVITY MEASUREMENTS

NIST radioactivity SRMs represent the national basis for accurate radioactivity measurements. A number of commercial companies provide secondary radioactivity standards, both for specific and general needs. These secondary standards are linked to the NIST produced national standards through intercomparison or traceability testing programs with NIST. Generally, the SRMs that are available from NIST are provided for one of several reasons: (a) they are not available from outside commercial suppliers, (b) commercially produced standards may not be traceable to national standards, (c) the accuracy of commercially produced standards is not adequate for a significant number of users, or (d) there are enough requests from the user community for a standard not otherwise available. SRMs for radioactivity measurements can typically be classified into three general categories: (1) environment and nuclear power, (2) medicine, and (3) basic and applied research using or involving radioactivity in the development of nuclear data and the examination of basic nuclear processes.

Since the beginning of the nuclear age, the importance of accurate radioactivity measurements has been recognized, especially in the development of nuclear power and nuclear medicine. Up until the 1940's, the major concern of physicists was the establishment of the physics and chemistry of nuclear processes. Therefore, the need for radioactivity measurements with higher accuracy became more urgent. Although some rudimentary metrology, as we now think of it, had been performed before the late 1940's, the development of a metrology-based discipline began around 1950.

The coincidence counting technique, although dating back decades, was developed into a primary measurement method by taking advantage of improvements in electronics and counting system design. The coincidence counting method became the cornerstone of the international measurement system for radioactivity, to which virtually all other indirect methods were referred. During the 1950's, the basic calibration factors for many radionuclides were established and retained on a stable and accurate ionization chamber at NIST (then NBS). With this set of definitive calibration factors, it was possible to begin assessing the accuracies of measurements made by users in commerce and research. This assessment was first done primarily in nuclear medicine and later moved into the nuclear power and environmental areas.

The NIST Radioactivity Group conducts a variety of programs in standards development, calibration services, traceability testing, and basic research to meet the requirements for new standards in radionuclide metrology, environmental monitoring, and nuclear medicine. Many research efforts lead to the development of unique radioactivity standards and measurements, which are transferred to industry via SRMs, calibration services, comparative measurements, and traceability testing programs.

Collaborations

Collaborations between NIST and the nuclear communities have resulted in many of the NIST traceability testing and measurement assurance programs. Participants include federal regulatory agencies, radiopharmaceutical manufacturers, commercial suppliers of calibration sources and services, and the nuclear power industry. One of the oldest and most important collaborations is the joint program with NRMAP, Inc. This program provides SRMs and other standards for quality control in the nuclear medicine and nuclear power industries. In the NIST Radiochemistry Intercomparison Program (NRIP), participants receive aqueous solutions, glass fiber filters, artificial urine and fecal materials, and soil that have been certified for strontium-90, uranium-234, uranium-238, plutonum-238, and americium-241 at levels as low as 0.03 Bq per sample.

The NIST natural matrix SRMs are a result of a collaboration of national and international environmental measurement laboratories. These natural matrix SRMs are distributed as ground, homogenized powders of soils, sediments, and organic materials and are characterized for as many as 20 radionuclides at environmental levels.

NIST Radioactive Standard Reference Materials Program

NIST issues a wide array of SRMs for radioactivity measurements. Typically there are 60 such SRMs in stock and calibrations have been performed on approximately 80 radionuclides. Uncertainties of these calibrations are typically 2 percent or less. These calibrations are performed using approximately 40 radiometric and a few mass spectrometric methods. The SRMs are issued in a number of configurations including gamma ray point sources mounted between thin plastic sheets, acidic solutions of alpha, beta, gamma, and x-ray emitting radionuclides, and natural matrix materials. NIST radioactivity measurements (SRMs, calibrations, etc.) are intercompared with the primary standards of other national metrology laboratories world-wide through the International Bureau of Weights and Measures (BIPM) which organizes and analyses the measurements.

The Radioactivity Group, which is part of the NIST Physical Measurements Laboratory, prepares the radioactivity SRMs listed in this brochure. Some of these SRMs are of short half-life (indium-111, iodine-131, molybdenum-99, technetium-99m, etc.) and are available only at certain announced times. Those of longer half-life are reissued periodically and may not always be available. If a NIST SRM of a particular radionuclide is not available, the following options should be considered.

Other Government Laboratories

Thorium, uranium, and plutonium-powdered ores, metal samples, and isotopic standards for mass spectrometry are available from the New Brunswick Laboratory, U.S. Department of Energy, 9800 South Cass Avenue, Argonne, Illinois 60439. For technical information call 1-630-252-2464. For general pricing and availability, call 1-630-252-2767, fax 1-630-252-6256, or email usdoe.nbl@ch.doe.gov. The NBL internet address is www.nbl.doe.gov.

The national standards laboratories of other nations offer reference materials of some radionuclides that are based upon calibrations that have been shown to be in satisfactory agreement with those of NIST through international intercomparisons. For additional information, contact the NIST Radioactivity Group. Call 1-301-975-5530, fax 1-301-926-7416, or email radsrms@nist.gov.

Commercial Standards Laboratories

Several firms in the U.S. prepare and distribute radioactivity reference materials. Prospective users of such products should ask suppliers if they participate in a traceability-testing program with NIST to ensure that the suppliers' calibrations are traceable to the U.S. national standards.

Calibration Services

The Radioactivity Group at NIST offers calibration services for over 80 radionuclides. However, there are limitations on the physical and chemical forms and on the activity of sources that may be submitted for calibration. A list of the calibration services available from the Radioactivity Group is available upon request and on the following internet address:
http://www.nist.gov/calibrations/ionizing-rad_index.cfm

Additional SRM Technical Information

The amount of a radionuclide in an SRM, at a specified time, is stated as

(1) the number of atoms, or
(2) the activity (the average number of nuclear transformations per second), or
(3) the emission rate of a particular radiation,

depending upon the method of calibration or the intended use. For solution standards, the quantity is usually specified per gram of liquid.

If the half-life is known, the number of atoms (or the mass) can be calculated from the activity and *vice versa*. If the fraction of radioactive decays that give rise to a specific radiation is known, the emission rate for that radiation can be calculated from the activity and *vice versa*. Suggested values of probability per decay for the more intense radiations usually accompany each SRM, or can be obtained from the NIST Radioactivity Group.

The old, traditional unit of activity is the curie (Ci), which is defined as 3.7×10^{10} nuclear transformations per second. By international agreement, the SI unit of activity is now the becquerel (Bq), which is defined as 1 nuclear transformation per second. Hence, 1 curie is equal to 3.7×10^{10} becquerels.

For additional technical information concerning a SRM in Category 205, contact the NIST Radioactivity Group.

NIST Uncertainty Statements

A measurement result is complete only when accompanied by a quantitative statement of its uncertainty. The uncertainty often determines the usefulness of the measurement result.

In earlier years, the uncertainties in most Radioactivity SRM Certificates were divided into "random" and “systematic” parts. The former, derived from the well-defined estimated standard deviation of the mean of a stated number of measurements and the assumption of a normal distribution, was given as the 99 % confidence interval of the mean. The "systematic" part was given as the linear addition of "limits" of other possible "errors" in the measurement system. The "systematic" part was clearly dominant for most radioactivity SRMs. To obtain an "overall uncertainty", the two parts were added linearly. If the uncertainty of the SRM needed to be propagated as a component of the uncertainty of a subsequent measurement, it was sometimes divided by three and treated as a standard deviation of the mean.

Discussions among representatives of eleven national standards laboratories, following the distribution by the Bureau International des Poids et Mesures (BIPM) of a questionnaire about uncertainty statements, led to BIPM Recommendation INC-1 (1980). The assertion is that the combined uncertainty of a measurement result is best characterized by the sum of the variances (or approximations thereof) that characterize the components. An expanded uncertainty is formed by multiplying the combined uncertainty by a coverage factor. (In accordance with NIST policy, a coverage factor of 2 is now used in all Radioactivity SRM Certificates).

This method of expressing uncertainties has been used for international intercomparisons in several fields without difficulty and has been implemented by all of the national standards laboratories. The publications below provide useful guidance, including definitions of terms and examples of calculations, when implementing this method.

[1] JCGM 100:2008; *Guide to the Expression of Uncertainty in Measurements*; (ISO GUM 1995 with minor corrections), Joint Committee for Guides in Metrology: BIPM, Sevres Cedex, France (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf

[2] B.N. Taylor and C.E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the

Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407. U.S.A. Single copies may be requested from NIST by sending a fax to 1-301-926-2884.

License Certification

U.S. Government regulations require all suppliers of radioactive material to verify, prior to shipment, that the purchaser is authorized to receive the type, form, and quantity of radioactive material that is to be transferred. For some SRMs, indicated in the NRC License/Certification or Equivalent Required column, NIST requires that all transfers shall have documentation that includes a current copy of the recipient's license issued by the NRC or an Agreement State. In addition, a certification from the recipient indicating that they are authorized to possess the type, form, and quantity of the SRM to be transferred is required. SRM purchasers should check any other regulatory requirements, if applicable, prior to acquiring the material.

The form below is a license certification that, when completed, will satisfy the requirements for a specific purchase order. However, a copy of the license should be submitted with your first order.

RADIOACTIVITY LICENSE CERTIFICATION REQUIRED BY

THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

(To be completed by the designated Radiation Safety Officer)

I hereby certify that _____
(Licensee)

is authorized to receive the following radioactive material:

(Type, form, and quantity of radioactive material or Standard Reference Material numbers)

_____

_____

_____

License or Registration Certificate Number: _____

Issuing Agency: _____

Expiration Date: _____

I further certify that I am authorized to act for and in behalf of:

_____
(Licensee)

to execute this certification.

_____
(Signature)

Reference: U.S. Code of Federal Regulations
Title 10, Parts 30.41, 40.51, and 70.42

_____
(Print Name)

_____
(Title)

_____
(Date)

This certification may be photocopied